

TUBERCULOMA OF THE LUNG.

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## INTRODUCTION.

During this century, as the role of the stethoscope as the main accessory in the diagnosis of pulmonary tuberculosis has been gradually usurped by the radiograph, the earlier, often silent, manifestations of this protean disease have been recognised. In recent years, with the fuller realisation of the potentialities of this invaluable diagnostic weapon in finding the early case and thereby helping to eliminate the disease in the community, we have witnessed a vast increase in its use, particularly since the introduction of mass miniature radiography.

Many new problems, clinical and administrative, have followed in the wake of this increase in the early recognition of disease, and a radiographic form of tuberculosis, often clinically silent, and peculiar in its problems, is being seen more frequently than hitherto. I refer to the so-called "tuberculoma of the lung".

## DEFINITION.

For the purpose of this study, a tuberculoma of the lung is defined as a rounded homogeneous opacity on the radiograph, with well defined borders, 1 centimetre or more in diameter, of a tuberculous nature.

It is a radiographic entity only and the term "tuberculoma", as used here, implies nothing other than a radiographic appearance.

Only in this way can its use be vindicated, for we are faced with the obvious criticism that we are using a pathological term to describe a lesion of unknown pathology seen on a radiograph - a practice deprecated by most physicians.

The term was first applied to these lesions in the belief that they were similar in their pathology and in their natural history to lesions so named in the brain, spleen and elsewhere. In fact, this is not the case. Their pathological and clinical picture is varied, and, in the main, quite different from the classical tuberculoma of the Pathology text-book. Mistaken as was this belief, it has introduced a term which, when used in a strictly limited sense, describes, with one word, a radiological appearance and indicates its aetiology.

Assmann's focus, solitary tuberculous focus, round focus, coin lesion, caseous nodular tuberculosis and localised caseous pneumonia are only some of the descriptive terms which have been used in the past by physicians, radiologists, and morbid anatomists. Against the last two and similar terms can be levelled the criticism that we are interpreting a particular pathological lung process into an x-ray plate. With tuberculoma, used in a limited sense, this is not so. Because of variation in their pathology, no one pathological term, used as such, is acceptable.



Assmann (1921 - 30) was responsible for directing medical attention to the appearance and significance of the sub-clavicular "infiltrate" as one of the earliest manifestations of adult-type phthisis. The lesions described were limited to the upper lobe, usually in the lateral part of the sub-clavicular region, and sometimes of the nature of a tuberculoma as defined above. An Assmann's focus, therefore, is any early "infiltrate" in this situation, which may occasionally be a tuberculoma, and it is unsatisfactory to use this term to describe the rounded lesions of tuberculosis elsewhere in the lung, in which the stage of the disease is unknown.

Solitary tuberculous focus is hardly descriptive of any particular radiographic pattern. Apart from this, careful scrutiny will often reveal other evidence of disease.

Coin lesion and round focus may describe a few of these lesions, but, if used in an exact sense, are too exclusive, and the aetiology is not indicated.

#### REASON FOR INVESTIGATION.

The literature on this form of pulmonary tuberculosis is surprisingly scanty and there is no uniformity of opinion on the various practical problems presented by these lesions.

Firstly, there is the problem of diagnosis. In many of these cases, where no clue of the tuberculous

nature is given by other evidence of phthisis, the possibility of primary malignancy may arise with all the operative urgency which that diagnosis may demand. The differential diagnosis is wide, but, by careful evaluation, diagnostic errors should be infrequent.

Once diagnosed, there is the problem of therapy. To be able to decide the merits and demerits of any procedure, it is necessary to have some knowledge of the natural history of such lesions - how they arise, what is their pathology, how they behave, and whether, by careful study, it is possible to judge the probable prognosis of an individual case.

#### MATERIAL.

The material, on which this study has been based, was found in the records of the Brompton Hospital between the years 1935 and 1950. It consists of all cases, coming within the chosen definition, in whom a minimum follow-up of 3 years could be obtained. A few cases, all subjected to resection, are the only exception to this temporal criterion. Only those cases have been included in whom the tuberculoma was the sole abnormality or appeared in association with minimal disease elsewhere in the lungs.

Initial case-finding was difficult as it entailed the scrutiny of the x-ray reports of all cases in which the radiologist suggested, in any way, the presence of a rounded lesion. In all, about 100,000 reports were investigated. After a preliminary screening of the material

postal enquiries were sent to all but those currently under surveillance at the hospital, and recent radiographs were obtained where necessary.

Only 41 cases are reported here, but this reflects, in no way, the incidence of this form of tuberculosis. Many more were found, mainly in latter years, but because of inadequacy of data, impossibility of follow-up, or short duration of surveillance, they have been discarded. There has been no selection apart from that imposed by the above criteria and the difficulties of case-finding.

To illustrate the pitfalls of diagnosis, a few cases of rounded lesions of different aetiology, simulating tuberculomata, are quoted; and there is one example of tuberculomata occurring in the course of cavitating lung phthisis.

#### GROUPING OF CASES.

In order to facilitate their study in relation to the various problems of diagnosis and treatment, the 41 cases have been divided into two groups as follows :-

Group A :- Those in which a tuberculoma was the only abnormality in the lung fields on the routine radiograph, (with the possible exception of lung or hilar calcification) - 29 cases, (Case Numbers 1 - 23 and 35 - 40 inclusive).



Group B :- Those in which a tuberculoma was the main lesion but in whom there was present minimal disease elsewhere - 12 cases. (Case Numbers 24 - 34 inclusive and 41).

The miscellaneous illustrative cases are numbered 42 - 45 (inclusive).

THE PROBLEM OF DIAGNOSIS.

The first problem to be faced when a patient presents with a rounded focus in the lung fields is to decide its nature. This is often difficult, the radiological possibilities are many, and little help may be gained from symptoms and signs.

Of the many disease processes which may appear in rounded form in the lungs, primary bronchogenic carcinoma constitutes the diagnostician's greatest hazard (Case 43). The following, also, may have to be considered in differential diagnosis :- Secondary neoplastic deposits; lung abscess, particularly the staphylococcal variety; localised bacterial and other pneumonias (Case 44); encapsulated pleural effusion or empyema; cysts, congenital and acquired; pulmonary hydatid cyst; coccidioidomycosis; gumma; and tumours such as adenoma, or more rarely, haemangioma, lipoma, neurofibroma, pleural fibroma, hamartoma (Case 45), and others.

To illustrate the difficulty with which we are often faced, only 17 of the 29 cases in Group A were confidently diagnosed as tuberculous at the first assessment. Of the remainder, there was doubt as to whether they were tuberculous or malignant in 9, and in the remaining 3, all of which were subjected to resection, neoplasm was diagnosed - in 2 cases bronchogenic carcinoma, and in the other neurofibroma. In Group B, where other disease was present, less difficulty arose. Only 1 case of the 12 in this group was diagnosed as other than tuberculous, (Case 30).



16.5.45.



9.1.47.

Fig. 1. Bronchogenic Carcinoma simulating Tuberculoma:

Case 43.

Female. Aged 35 years. X-rayed (16.5.45) as contact of her husband. Diagnosed as tuberculoma and kept under observation as an out-patient. The patient remained well until October 1946, when she began to lose weight. The lesion, stationary until then, began to enlarge slowly. In March 1947, developed signs of intracranial disease and died 26.5.47. At necropsy: adenocarcinoma of lung with secondary meningeal carcinomatosis.





4.1.39.



30.1.39.

Fig. 2. Transient Lesion diagnosed as Assmann's Focus:

Case 44.

Female. Aged 19 years. At the time of first x-ray (4.1.39), was recovering from "influenza". Symptoms rapidly disappeared and by 30.1.39, resolution of pulmonary focus was almost complete. Subsequent progress uneventful, and further x-rays clear.



Fig. 3. Tuberculoma  
diagnosed as Bronchogenic  
carcinoma:

Case 35.

Female. Aged 29 years.  
The lesion was observed  
to enlarge on serial  
x-rays. All investigations  
negative, including  
examination of sputum.  
R. Pneumonectomy performed  
(7.5.41). Developed  
tuberculous empyema and  
broncho-pleural fistula.  
Died 18.4.43.



Fig.4. Tuberculoma  
diagnosed as ? Neurofibroma:

Case 36.

Female. Aged 35 years.  
R. Upper Lobectomy  
(26.1.43).  
Uneventful recovery.

Further illustration is provided by cases 43, 44 and 45, all of which were thought to be tuberculous until proved otherwise.

#### CLINICAL INVESTIGATION.

From the foregoing, it is apparent that thorough investigation is obligatory and, wherever possible, there should be no delay. Fortunately, it is rarely necessary, in the first place, to wait until a bed becomes available, for much can be done by out-patient assessment.

The importance of a careful history and examination need not be stressed. On the history alone, a presumptive diagnosis may be made, but it is unfortunate that, in many instances, little of positive value may accrue from it.

Age: In this series, the average age was 29 years, the youngest being 15 and the oldest 51.

Tuberculomata are most commonly found between the ages of 17 and 35. Tuberculosis is the most common cause of round lesions in this age period and one is justified in saying that, all things being equal, when a symptomless patient, between these ages, is found to have a round lesion in the lung parenchyma, tuberculosis is the most likely diagnosis. Neoplasm, either primary or secondary, can occur at any age, and, of course, cannot be excluded on such flimsy grounds. As the age of 40 is reached and passed, malignancy becomes the most likely cause until proved otherwise.

Sex: In the experience of others (Holmes Sellors and Hickey, 1949), and in this series, tuberculomata have been found more frequently in females, (27 females, 14 males). Primary bronchogenic carcinoma is more common in the male sex, but no inference can be made from this observation.

Family Contact and Past History: 43% of cases in Group A gave a strong family or contact history of pulmonary tuberculosis. Such a history, taken in conjunction with other factors may be of some value in establishing a presumptive diagnosis. To a greater extent, a past history of dry or wet pleurisy or extra-pulmonary tuberculosis may be of assistance.

Symptoms: The silent and asymptomatic nature of many of these lesions has been frequently noted, (Bruck, 1934, Fruchter, 1935, etc.). In Group A, 12 cases had no symptoms whatsoever, and they were found at routine chest radiography. All but 2 in Group B had relevant complaints.

Assmann was the first to mention haemoptysis as an early symptom and such has been the experience of more recent authors. The haemoptysis, often unheralded by other symptoms, is rarely large in amount, taking its usual form in streaking of the phlegm or a few small clots. Nearly half the patients in Group A with a symptomatic history had had an haemoptysis at one time, and in 2 cases it was the first symptom.



Pleuritic pain, as the chief presenting symptom, was surprisingly common - occurring in 20% of the cases in Group A.

Other symptoms usually associated with early tuberculous infection, cough, a little sputum, slight fever, lassitude, loss of weight, etc., were present either with haemoptysis or pleurisy, or alone, in the remaining patients.

Duration of symptoms: This and the mode of onset is always of importance, and may be helpful in the differentiation from malignant and acute inflammatory processes. The longest duration of ill health in Group A was 3 years with an average duration of approximately 1 year. It must be remembered, however, that cases of bronchogenic carcinoma of the squamous cell type may live with modest symptomatology and minimum radiographic change for 2 years and more. Case 43 is an unfortunate example.

Signs: These are rare, (only 2 cases in Group A), and often of no positive value. A thorough clinical examination, however, is an essential diagnostic measure, if only to eliminate other possibilities.

Sputum: Sputum where present is usually minimal in amount and innocent in appearance. The search for acid-fast bacilli must be carried out diligently before the sputum is considered to be negative and, even then, the diagnosis of tuberculoma is in no way excluded. Of the cases in Group A, 20 never had a positive sputum

throughout the observation period and in only 3 was the tubercle bacillus found at the time of initial investigation, thereby making the diagnosis.

Unfortunately, in only a few instances, was the search sufficiently diligent to allow the statement that these 20 cases never had a positive sputum. Many, however, were seen in an arrested phase on first attendance, especially those found by routine radiography, and in these cases a positive sputum was unlikely.

The finding of a few acid-fast bacilli on one smear examination does not give sufficient evidence per se to diagnose tuberculosis. In these cases, however, where the bacilli are notoriously hard to find and few in numbers, one positive finding has been deemed sufficient by the managing physician in a few instances, usually when taken in conjunction with other evidence of phthisis.

It must be remembered also that a positive sputum does not exclude bronchogenic carcinoma or other diagnosis. Two diseases may co-exist in the lungs or, more perplexing still to the physician, a new growth or inflammatory process may stir up infection in a dormant tuberculous focus. Admitting this possible but rare source of error, a positive sputum, on more than one occasion, offers incontrovertible proof of a tuberculous aetiology, and without it, the diagnosis must often be made in time or on the operating table.



Examination of the sputum by all modern methods should be made in all cases and repeated at frequent intervals. Communication of the lesion with a bronchus may be intermittent and transient, and it is only at these times that sputum positivity is anticipated. Apart from routine examinations of smears of sputa, laryngeal swabs, gastric washings and cultures should always be made. The delay entailed in the maturation of cultures may not be merited when the scales weigh heavily on the side of primary neoplasm, but, in practice, this time often elapses before resection is performed, and it may save the patient the loss of much valuable lung tissue, the result of precipitate surgery.

Apart from the question of diagnosis, a positive sputum appearing during observation of a tuberculoma may indicate reactivation of the lesion before the radiograph shows any change and will indicate the need for greater care in surveillance and treatment.

Before leaving the subject of sputum in these cases, mention must be made of the dangers involved in placing reliance on the finding of malignant cells in the sputum. Case 37 serves as an illustration.

Tuberculin Testing: In only 5 of all the cases reported here was any form of tuberculin test performed and all were positive to a Mantoux test in the higher dilutions. 4 of these cases were in Group A, where the diagnostic problem arose. In this hospital, serving, in the main, an urban population, the proportion of

positive reactors in adults is so high that the managing physicians did not consider it worth while. It is felt, however, that its application in doubtful cases is merited by the value of a negative reading. Holmes Sellors, on the other hand, states that the Mantoux reaction is often only weakly positive, but I have been unable to find any record of negative Mantoux with tuberculomata although this is patently possible.

Erythrocyte Sedimentation Rate: The E.S.R. was estimated at the time of first attendance in 31 instances. In Group A it was over 10 mm/hr (Westergren) in only 3 cases and under 10 mm/hr in 18 cases. In Group B, the corresponding figures are 2 and 8 respectively. This test is of no diagnostic value but it may be of value as a warning of activity. With one exception, all cases with a raised E.S.R. showed a changing lesion on serial radiographs, but activity was seen to occur in the presence of a normal reading.

#### RADIOGRAPHIC INVESTIGATION.

Routine postero-anterior and lateral films should be the rule in all cases. Not only is it necessary to determine that the lesion is truly endothoracic, but, as in all diseases of the chest, accurate localisation within the lung fields is a pre-requisite to diagnosis and treatment. Without a lateral film, any attempt at this is pure guesswork.



Fig. 5. Hamartoma diagnosed as ? Tuberculoma: Case 45.

Male. Aged 50 years. Lesion found at Mass Radiography. No symptoms. Small densities in centre of lesion were interpreted as calcification in a ? tuberculoma.

R. Upper Lobectomy (3.1.50) "in view of possibility of lesion being a carcinoma or a tuberculoma". Convalescence uneventful.

Histology: Hamartoma of the lung, containing 7 or 8 pearly-white masses of cartilage. There were also wide areas of fat and primitive connective tissue, in which many ducts, lined by a bronchial type of epithelium, were present.





8.10.45.



2" P.A. Tomograph 13.12.45.



3.2.50.

Fig.6. Demonstrating the value of Tomography in determining the nature and position of the lesion: Case 22.



Fig. 7. Demonstrating typical cavitation of a tuberculoma:  
Case 30.

Nipple shadows, extrapulmonary lipomata, enlarged glands, tumours of the ribs and chest wall can all appear as round opacities on a postero-anterior plate, but these can be excluded by the lateral film. A spherical shape may be a feature of such a lesion as an encysted effusion or a subsegmental collapse-consolidation in one plane, but this is lost in the other.

Where position is not absolutely defined in these views, or where, because of superimposition of osseous or vascular shadows, the lesion cannot be seen in its entirety, other projections or tomography may be required.

Tomography is a powerful weapon in the elucidation of such lesions and where any doubt exists as to position, diagnosis, or activity, its use is strongly advocated.

Radiological features of Tuberculomata: As already defined a tuberculomata is a rounded homogeneous shadow with well defined borders, 1 c.m. or more in size, of a tuberculous nature. In this series all are rounded but few are perfectly round. They may be oval, ovoid, or irregular in outline, but in all, the general configuration suggests rotundity. Not all are perfectly homogeneous. This, too, is a relative term denoting a background of uniform density. A lesion may appear homogeneous on straight radiography and yet on tomography



either cavitation or variations in density are seen. Vice versa, a homogeneous lesion on the tomograph, by superimposition of vascular or other markings, may appear anything but homogeneous on the straight radiograph.

(a) The size of the lesion in this series, varies between 1 cm. and 5 cm., but cases have been reported of greater dimensions.

(b) Tuberculomata may be multiple (Cases 31 and 42). Bruck (1934) describes a case where 14 tuberculomata, simulating neoplastic metastases, were present.

(c) The segmental distribution of these lesions is of interest. No part of the lung is exempt, but the sites of election are the posterior segments of the upper lobes and the apical segments of the lower lobes. The right lung is more commonly affected than the left. It will be noted that the right middle lobe and lingula on the left side were not involved. Recently, an example of a proven tuberculoma in each of these sites has been seen elsewhere. The sites of election are those frequently affected by aspiration of infected material in the recumbent position and are common sites for tuberculous disease of the lungs, either primary or post-primary.

Table 1. Segmental Distribution. (41 cases).

	Upper Lobe				Lower Lobe			Right middle lobe or lingula	Lobe not known	Total
	Ant seg	Post seg	Apic seg	Seg not known	Apic seg	Other seg	Seg not known			
Right lung	2	7	5	4	7	2	0	0	1	28
Left lung	0	1	1	5	4	0	0	0	2	13
	2	8	6	9	11	2	0	0	3	41

(d) There is considerable variation in the density of the opacity cast by these lesions, and, therefore, in their relative prominence in the lung fields. Some are of low density, soft in appearance and poorly demarcated from the surrounding normal lung; others are dense, sharply defined, and stand out in relief. It is in this latter type that the presence of an enveloping capsule is often inferred, but it is doubtful whether such an inference is justified. Variations in density frequently occur in older lesions and the peculiar pattern of concentric laminations is described (Haight and Farris 1939). This variation in density and prominence is probably dependent on several factors including radiographic technique, the age and size of the lesion, and its activity. Because a tuberculoma is dense and well demarcated, it is not necessarily innocent.

Satellite infiltration and other tuberculous

disease: In Group A, there was no such evidence seen on the routine radiographs; in Group B, tuberculous disease, either adjacent or remote was present. The presence of infiltration is one of the more important observations in favour of a diagnosis of tuberculosis. It may be minimal and only appear on tomography. Of the 8 cases tomographed in Group A, infiltration, previously unobserved was seen in 3. Frequently it is situated peripheral or adjacent to the tuberculoma, suggesting local spread by aspiration, or possibly by lymphatics, but it may be remote.

While this is presumptive evidence of phthisis, it must be taken in conjunction with other factors. Its absence has no significance.

Calcification of the lesion: Calcium may be deposited in older foci, and, as well as being strongly in favour of a tuberculous aetiology, it suggests that healing is taking place. It may be too small to be readily recognised, or covered by rib shadows on the routine films, but tomography will demonstrate its presence.

Calcium deposition in the lung parenchyma occurs in other conditions, (Kayne, Pagel and O'Shaughnessy, 1948) but they are either rare or uncommon in this country. Case 45 demonstrates a hamartoma in which the typical seedling opacities of cartilage were mistaken for early calcification in a tuberculoma.



Cavitation: When a tuberculoma cavitates, the typical picture is that of single or multiple eccentric translucencies, irregularly shaped, rarely circular, but of smooth outline, surrounded by the thick homogeneous mass of the lesion. No fluid level is seen. Presumably part of the lesion has communicated with a bronchus with discharge of caseous material. Again tomography is the best means of demonstrating the presence of this cavitation.

This unusual radiological picture is rarely simulated by a breaking-down carcinoma for there the walls of the cavity tend to be more irregular, a fluid level is frequently present, and there may be evidence of bronchial occlusion. Blood and echinococcal cysts might be confused but here the outline of the eccentric translucency is typically crescentic. In Case 7, a blood cyst was diagnosed at one time, because of such an outline, but on careful inspection, this was more the shape of an inverted comma than a crescent. The finding of tubercle bacilli in the sputum clinched the diagnosis.

When cavitation is present, isolation of the tubercle bacillus might be expected with greater ease.

Hilar Adenopathy: This feature is conspicuous by its absence, except in the occasional case, and this fact is frequently quoted in the literature in favour of a post-primary pathogenesis. In one of the patients under discussion (Case 15), an enlarged hilar gland was

suspected and subsequently proven by its retrogression and calcification. It is known that a primary focus may appear in rounded form. The occurrence of hilar adenopathy, therefore, raises this possibility as well as suggesting alternative diagnosis.

#### OTHER MEASURES.

Bronchoscopy: As an adjunct to confirmation of tuberculous aetiology, or the exclusion of a new growth or other pathology, this procedure is rarely of value as the tumour is usually situated without the range of endoscopic vision. No abnormality was found in any of the 6 cases in this series in which bronchoscopy was performed as a diagnostic measure.

This observation does not deny its use in certain cases, but, on the whole, negative results are to be expected. Examination of bronchial aspirates occasionally may provide bacteriological confirmation of phthisis.

Diagnostic Artificial Pneumothorax: Jacobaeus and Key (1921) recommended the use of artificial pneumothorax, followed by thoracoscopy, as a diagnostic measure in intrathoracic tumours.

This manoeuvre is rarely practised to-day, as inspection of the tumour, when possible, seldom facilitates the diagnosis. In certain cases, however, a diagnostic pneumothorax, with radiography, may be necessary to discriminate between pulmonary and extra-

pulmonary lesions.

### SUMMARY.

After careful investigation and assessment, the diagnosis may remain uncertain. Two courses are open. If the suspicion of malignancy runs high, immediate resection is the way of choice. If, on the other hand, tuberculoma or other non-malignant condition is suspected but not confirmed, a more conservative policy can be adopted.

Exploratory thoracotomy is mentioned as a diagnostic step in surgical writing, (Mc Mahon and Forsee, 1949, Dahl-Iverson and Møller, 1946.), but no case can be found, when, a tuberculoma being present, this did not result in resection. There is no certain way of ascertaining the nature of the tumour when the pleura is open, although palpation of the lung may decide between segmental resection, lobectomy and pneumonectomy. Resection follows in natural sequence and only on pathological examination is the tuberculous nature confirmed. The decision to resect or not to resect must be taken; exploratory thoracotomy is merely a euphemistic name for resection in these cases.

Some modern opinion appears to advocate major surgery in all doubtful cases. As bacteriological confirmation of a tuberculoma may be difficult to obtain, this means resection in many patients who would be



diagnosed otherwise by their behaviour in time, and who might live a full life, without the burden of a serious operation and the loss of useful lung tissue. The merits and demerits of resection as a therapeutic measure for tuberculomata will be discussed later. It is sufficient, for the present, to deprecate its use in all undiagnosed solitary round shadows in the lung.

In this series resection was performed in 7 patients (Group A - 6 cases; Group B - 1 case). The pre-operative diagnosis in 3 cases was neoplasm; in 2, neoplasm or tuberculoma; and in only 2 was the diagnosis confirmed pre-operatively.

THE NATURAL HISTORY OF TUBERCULOMATA.

A study of the literature reveals many and divergent opinions on the morbidity of tuberculomata. Haughton (1950), in a recent article, regards them in the nature of "time-bombs", liable to explode at any time into florid tubercle. Their potential instability is advanced as the main reason for their extirpation by the thoracic surgeon, (Thornton and Adams, 1942, Holmes Sellors and Hickey, 1949, etc.). Earlier observers in general recognised the danger of breakdown and spread but Bruck (1934) propounded the view that most remain quiescent. We know that some of these lesions are manifestations of primary tuberculosis and others are inspissated cavities. In the former, the local prognosis is good, and the latter is considered by the clinician and morbid anatomist to be a healing lesion.

Clinical impression based on the experience of single or only a few cases, treated in various ways, forms the background for most prognostications. There is only one study in the world literature in which any attempt at a scientific approach to the clinical aspects of the problem has been made. In 1949, Eriksen, in Norway, carried out a follow-up investigation of 40 cases of tuberculoma, with an observation period of between 2 and 11 years. At the end of this time 38 of the 40 were alive and well, and treatment was conservative in all but 3.

Excluding the 7 resection cases in whom the natural history was artificially forestalled, there remain for consideration 23 cases in Group A and 11 in Group B. Of these, 6 in Group A and 4 in Group B received some form of minor collapse therapy. The remaining patients either had no treatment at all or received a period of bed rest only.

The relevant particulars of all cases are presented in the appendices - the cases being sub-grouped according to the therapy received.

Study of those cases in whom there was no major surgery demonstrates several different but definite patterns of behaviour. Each case can be placed in one of the following broad groups :-

- (1) Those in whom the healing process was  
uneventful 17 cases.
- (2) Those in whom evidence of activity  
was manifest at some time but was  
followed by healing 14 cases.
- (3) Those in whom active pulmonary phthisis  
persisted or was present at the time  
of last attendance 3 cases.

#### THE PROCESS OF HEALING.

As in any other tuberculous disease the standards by which the process can be adjudged as arrested or healed are controversial, and the proper application of these terms is a matter of great difficulty.

It is known that viable tubercle bacilli may be locked for years in healed, cicatrised, tuberculous tissue, and that endogenous reinfection with these bacilli may be responsible for reactivation of a so-called healed lesion many years later. Case 26, where, after an interval of 10 years, reactivation and cavitation occurred, is a possible example. The presence of this knowledge constitutes an ever-present qualification to any final assessment of cure, but, admitting this, such a judgement can be reached by careful correlation of clinical findings with serial radiographs - greatly aided by the passage of time.

The healing process is common to other forms of pulmonary tuberculosis, namely, resolution and fibrosis, with calcification in its role as a final by-product of caseation. The usual sequence of events commences with diminution in size and increase in density. Hard, fibrotic streaks then appear, possibly followed by calcium deposition, and slowly thereafter, the homogeneous background of the lesion resolves, leaving scarring and calcium as the only witness of previous abnormality.

The time required to pass through these phases in any individual is dependent on many factors, known and unknown. As the cases herein were not observed ab initio but found when the tuberculoma had been present for an unknown period of time, elucidation of this point by their analysis is not possible. It is sufficient





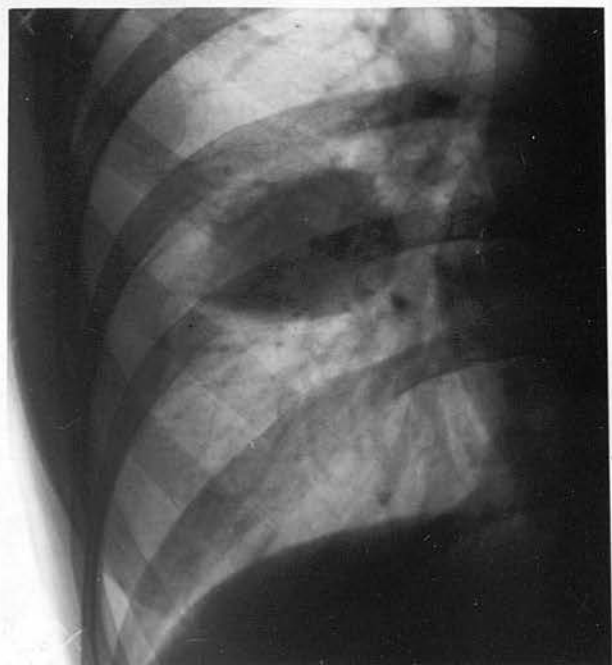
6.9.34.



20.4.39.

Fig. 8. The Process of Healing: Case 25.

In 5 years, the process of resolution is almost complete and calcium deposits have appeared in the lesion and adjacent disease.



9.5.46.

A.P. Tomograph 8.11.46. (3 cm).



6.1.50.

Fig. 9. The Process of Healing: Case 9.

Note cavitation on tomograph. This disappeared rapidly and since then the lesion has become more dense and better demarcated. Early calcium deposition has commenced, and calcium has become evident in both hilar regions.

to say that there was no proof that therapy shortened the process of healing, once it had commenced.

Close correlation was found between clinical and radiographic improvement. Symptoms and signs of activity, such as sputum positivity and elevation of the E.S.R., were never found during surveillance with evidence of a healing or inactive lesion on the radiograph. Of the 17 cases who proceeded uneventfully to apparent healing, 7 had symptomatic or other evidence of pulmonary disease at their first visit, but all regained their health soon thereafter, possibly aided by appropriate therapy in all but 1.

#### SIGNS OF ACTIVITY.

Radiologically a tuberculoma may demonstrate activity in three ways. It may enlarge; it may cavitate; or evidence of spread may appear in the lung parenchyma or to the pleura. All these phenomena may be seen in a single patient but commonly one of the first two stages of this triad is missed possibly because of its transiency in relation to the time interval between x-rays. Thus infiltration or a small pleural effusion may be unassociated with any alteration in the dimensions or in the texture of the offending lesion, (Case 22). In such circumstance, an attempt might be made to exonerate the tuberculoma, postulating activation of a previously invisible focus. However, in the presence of an obvious potential source of trouble, it is hardly justifiable

to suggest an alternative cause. It is a different matter in Group B cases where other disease was present already, for here it is impossible to say, in some instances, which came first, the tuberculoma or the infiltration.

Table 2. Cases showing radiological activity and subsequent healing.

	Cavitation alone	Cavitation and spread	Spread alone	Activity of other disease
Group A	2 (7,9)	3 (8,19,20)	3 (6,12,22)	-
Group B	3 (28,33,34)	2 (30,32)	0	1 (31) <sup>⌘</sup>
Total: 14	5	5	3	1

N.B. Case numbers are in parentheses.

⌘ Infiltration became a tuberculoma.

The following patients have active disease at the present time :-

1. Case 17. Active lesion at onset, which healed rapidly to a fibrous streak, within 2 years. Developed extensive disease in contralateral lung after further 2 years. Tuberculoma remains healed.
2. Case 26. Inactive lesion initially. Good health for the next 8 years but no surveillance. 10 years after first attendance found to have tension cavity in the site of the earlier focus.
3. Case 29. Tuberculoma cavitated and cavitation persists 3 years later.



Is there any warning of impending breakdown?

The size, definition, and density of the lesion are of little assistance in the individual case, although a well defined, hard, focus rarely causes trouble. The large lesions are more suspect than those of smaller dimensions.

Fortunately, other more definitive warnings may be present. Foremost of these is the development of ill-health in a previously asymptomatic patient, especially when such symptoms as haemoptysis and pleural pain occur. Radiographic activity was preceded by symptoms in 65% and in a further 10% symptoms were present thereafter. On the other hand, a definite but smaller proportion of cases, who proceed uneventfully to healing, present with identical symptomatology.

Radiographic enlargement on serial x-rays was briefly noted on page 25 as evidence of activity. This may take place over many months (Case 19) or enlargement may not be noticed until cavitation has occurred. Apart from those in whom this observation resulted in resection (Cases 35, 39, 40), an enlarging lesion was invariably followed by cavitation, a positive sputum, or fresh disease. It should be noted that this phenomenon of enlargement is frequently the reason for diagnosis of a round focus as a tumour.

A positive sputum test is frequently the harbinger of trouble. In the whole series, activity occurred in 17 cases and in 13 a positive sputum was

found. Further, in 2 of the resection cases, in whom the lesion was seen to enlarge, the sputum contained tubercle bacilli. Only 3 cases showed tubercle bacilli in the sputum in the absence of radiological activity and in 2 of these it was during a period when serial radiographs were not available. In many instances, however, sputum positivity was not found until after the appearance of radiological breakdown.

A rising E.S.R. is of less value, because of the possibility of other cause and because of the frequency of normal values with active lesions, but in this series, where the E.S.R. rose above normality, breakdown was found in all but one.

#### The Behaviour of Cavitation:

The appearance of the typical cavitation of tuberculomata has been described. Once it has occurred, it may disappear as it came or it may persist, becoming the usual tuberculous cavity and carrying with it, all the problems thereof. When frank cavitation develops, it is of the type with spherical outline and a fluid level, usually associated with a large tension element. As is frequently observed with this latter type of cavity, alternative opening and closing over a period of months may occur, with, all the time, a liability to metastatic infiltration.

Table 2 shows that cavitation occurred in 10 cases of whom 5 had new infiltration, and yet all proceeded towards healing, with or without therapy.

Of the 3 cases in whom cavitation still persists, only in one can a direct sequence from a solid tuberculoma be traced. A further example of tension cavitation developing from the usual tuberculoma translucencies (Case 30) would undoubtedly have been included with these latter cases, had not streptomycin therapy reconverted the cavitation into a homogeneous lesion and turned the tide towards recovery.

The Behaviour of Co-existent Disease:

Fresh infiltration is frequently adjacent to the original lesion, either in the same or related broncho-pulmonary segment or subsegment. If it is remote, it is commonly found in segments of the ipsilateral or contralateral lung most likely to be affected by aspiration metastases, namely in the apex of the lower lobe or in the posterior segment of the upper lobe.

It is unlikely that the lymphatics and blood stream play much part in this dissemination. Communication occurs between the lesion and the bronchus or bronchiole to the affected part and caseous material is aspirated into these vulnerable areas of the bronchial tree, where, the ground being fertile and virulent bacilli present, a fresh tuberculous process may originate. Presumably, the degree and duration of this communication, and the resistance, local and general, of the host, will be the determining factors governing what is found on the radiograph and what happens to the patient. Typical



cavitation may appear or this may be missed and only the new focus remain to tell the tale of misfortune.

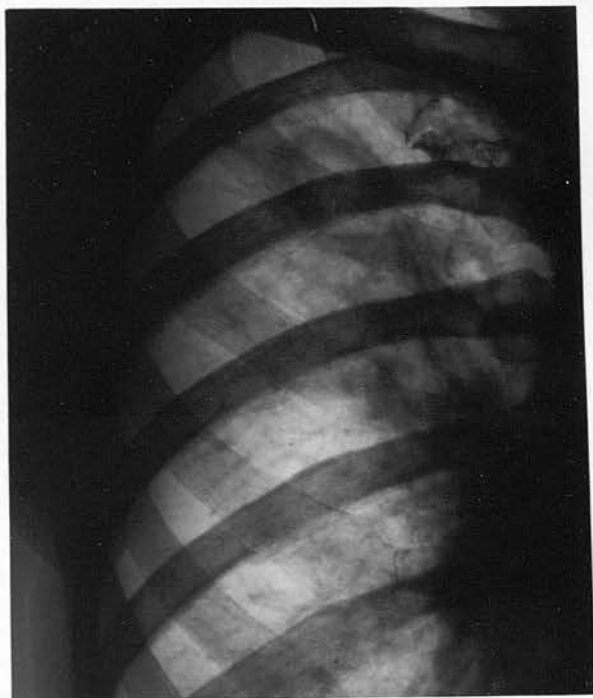
When spread occurs, the radiographic features may be those common to tuberculous infiltration, but there is a definite tendency for further round foci to occur, either from the beginning or as a slow development in a patch of infiltration. This seeding off from the original lesion offers an explanation for multiple tuberculomata. Of the 5 cases in Group A who developed fresh disease during observation, this disease took the form of tuberculomata in 60%, and in Group B, infiltration was seen to coalesce into a homogeneous round lesion in 2 cases. Case 42 is a further example. These new tuberculomata are presumably subject to the same dangers of breakdown as the parent lesion, but in all 6 instances their further course was towards healing.

The literature contains references to the fact that tuberculomata may remain static or proceed to heal, in the presence of progressive lung phthisis. Such references are probably based on cases where a rounded lesion is present in association with a considerable amount of disease - a type of case not included here, as no peculiar problems arise. It is a remarkable fact that, in Group B (12 cases), where there was limited attendant disease, and in the 6 cases in Group A who developed further parenchymal involvement, in not a single instance has progressive phthisis occurred



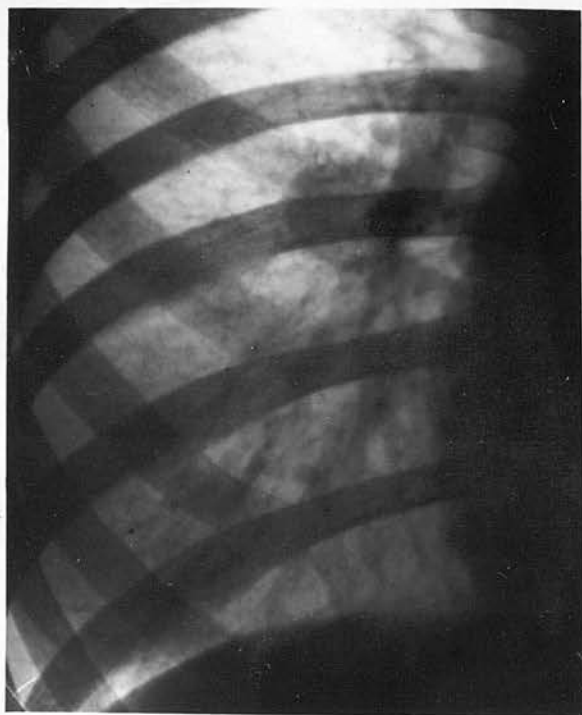


1.11.38.

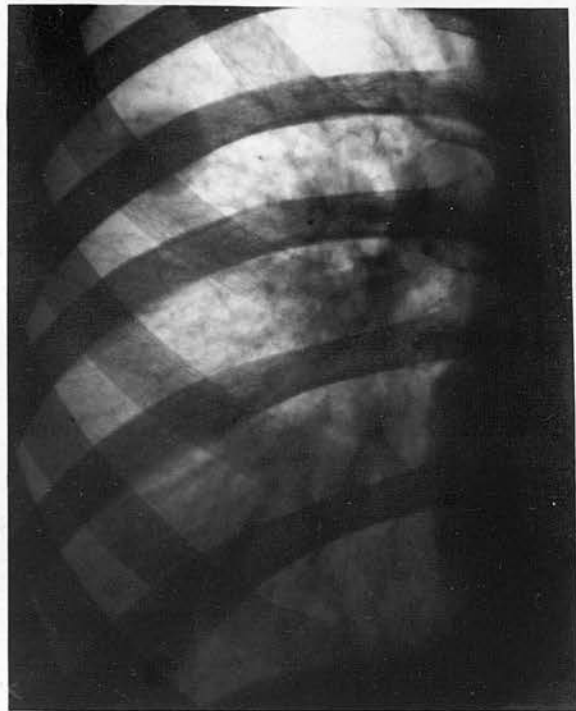


5.7.49.

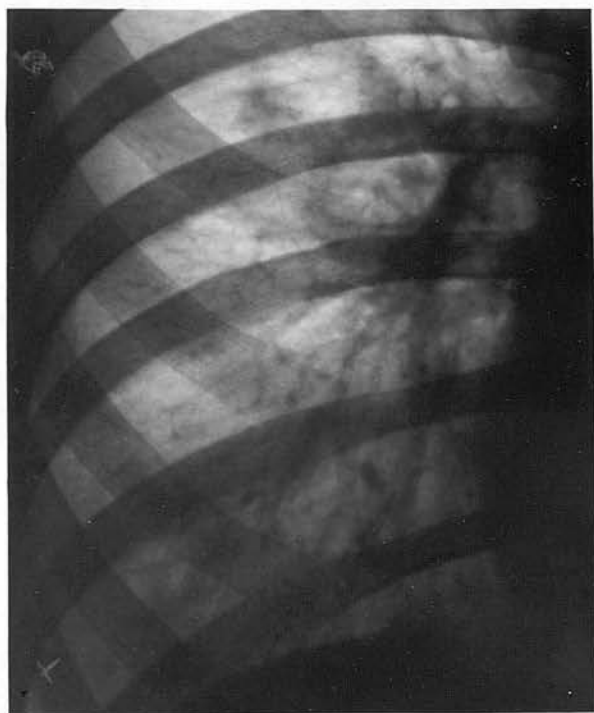
Fig. 10.    Reactivation of disease, with cavitation, after  
an interval of 10 years:    Case 26.



13.8.46.



2.6.47.



2.9.49.

Fig. 11. Development and persistence of tension cavitation:

Case 29.

A "daughter" tuberculoma appeared and subsequently regressed.

Fig.12. Development of  
daughter tuberculomata  
from spread disease:

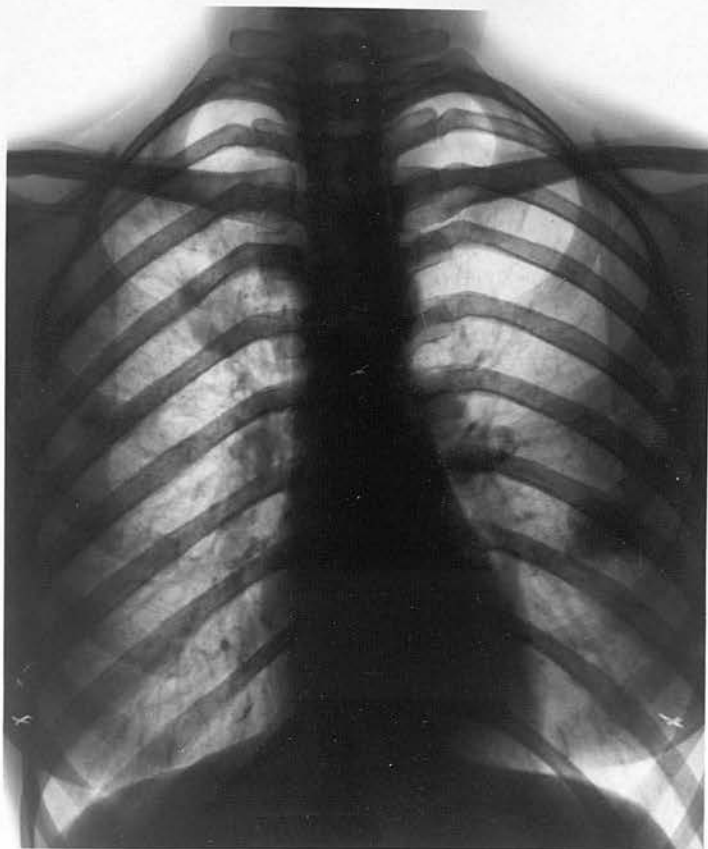
Case 42:

Female. Aged 18 years.  
In 1938 found to have  
tuberculous infiltration  
and cavitation in the  
right upper zone, and a  
small area of soft  
infiltration in left  
mid. zone.

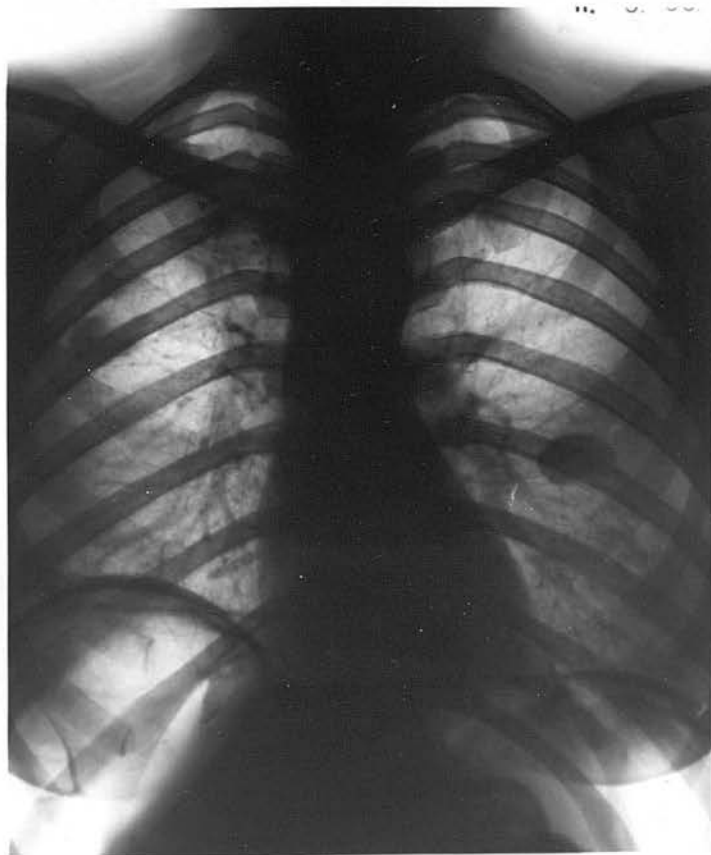
Cavity closure, and  
resolution and hardening  
of infiltration resulted  
from 8 months bed rest.  
Remained in good health  
until October 1945, when  
sputum was found to  
contain tubercle bacilli.

X-ray at this time  
showed 3 separate  
tuberculomata in the  
positions of previous  
cavitation and infil-  
tration. The uppermost  
lesion on the right  
side contained a central  
translucency.

Treated with bed rest  
aided by a pneumoperitoneum  
and right phrenic crush,  
the cavitary lesion  
slowly resolved, and  
the other tuberculomata  
have become more dense  
and better demarcated  
from the surrounding  
lung. In the past 3  
years, the patient has  
remained in good health,  
attending hospital for  
pneumoperitoneum refills.



4.10.45.



11.3.50.

in the absence of activity of the tuberculoma itself, (except in Case 17, where, following healing of the tuberculoma, progressive phthisis developed in a new site 2 years later).

There is an instance of confluent tuberculous bronchopneumonia followed by a mixed empyema (Case 8) which, in pre-streptomycin days, resolved completely with bed rest and drainage of the empyema.

If the main lesion remains sealed off from the bronchial tree, it would appear that the subsidiary disease carries a good prognosis and will heal in time.

#### SUMMARY.

A tuberculoma can hardly be regarded as a "time-bomb" for not only does it lack true explosive qualities if properly watched, but a trail of pulmonary devastation rarely results. However, its potential instability cannot be denied for in the 34 cases not subjected to surgery, activity was manifested at one time in 50%.

It must be stressed that this high incidence of instability was found in a Chest Hospital where cases are referred for consultant opinion and therapy and are therefore, to some extent, selected, showing a higher incidence than would pertain in an unselected group.

The prognosis is good. There were no deaths and only 9% had active pulmonary tuberculosis at the end of surveillance. This is further reduced to 6% by



exclusion of Case 17 where recrudescence of activity cannot be related to the tuberculoma.

To what extent the natural history and prognosis is affected by therapy will be discussed later.

PATHOLOGY OF TUBERCULOMATA.

Tuberculoma is not a pathological entity.

Three distinct patterns are seen :-

- (1) a post-primary caseous pneumonic process,
- (2) an inspissated cavity,
- (3) a primary lesion.

Assmann (1921-30), Stefko (1928), Beitzke (1931), and others, described the histology of the rounded form of early infiltrate as an exudative process, a localised tuberculous bronchopneumonia in which caseation might be found, and which might involve a bronchus, discharge its contents, and assume cavitary characteristics. Small contiguous foci were frequently present and the primary lesion was surrounded by a capsule of varying density and varying morphology, according to the age and chronicity of the lesion. They were considered to be reinfection foci of exogenous source, mainly because hilar adenitis in association was an uncommon phenomenon.

Straub (1932), in a masterly review of reported cases of round lesions, described them as structureless, caseous or partly calcified foci, with a surrounding fibrous tissue capsule, which was sometimes hyalinised, and which found their origin in coalescence of post-primary haematogenous exudative foci. They represented a rare form of development of exudative focal tuberculosis.

Following the work of Coryllos (1933, 1936) on the mechanics and biology of tuberculous cavities, in

which the paramount importance of the bronchial outlets in their evolution and fate was demonstrated and proven by experiment, a new stimulus was given to the study of cavity healing. Blockage of the drainage bronchus, resulting in an inspissated cavity became a recognised method of healing. Graeff, (1935) was probably the first to offer pathological proof of this by describing such a case. Amberson, (1936), Derscheid and Toussaint, (1938), Pagel and Simmonds, (1939, 1942), Auerbach and Green, (1940), and others, followed with further pathological studies in which closure of the draining bronchus by kinking, oedema, granulation tissue, fibrous stenosis or caseous plugs, resulted in isolation and inspissation of the cavity. Pagel, in a recent survey of this subject (1948), states that, in the cases reported in the literature, this process is the most frequent mode of cavity healing. "Within four weeks, a cavity can be converted into a solid nodule. At first this focus is soft and cannot be regarded as a stabilised or healed lesion, but later, when the material becomes more and more inspissated and calcifies, it deserves the latter designation".

When the bronchus is blocked, caseous material can no longer drain, air is absorbed, and on the radiograph, a rounded homogeneous tuberculoma replaces the cavitation. This is a frequent observation in the treatment of cavitary phthisis by collapse therapy and other means. Alteration of the broncho-cavitary relationship causing kinking is probably the *modus operandi*

of cavity closure in many cases of pneumothorax and pneumoperitoneum, while reliance is placed on caseous plugs in such therapy as reversed postural drainage, proposed by Dillwyn Thomas, (1948).

Clinically, it is usually a matter of extreme difficulty to determine the pathogenesis of tuberculomata - whether they represent pre-cavitary foci of caseous pneumonia or whether they are inspissated cavities. In a few, development from small areas of infiltration will be observed (Case 31), but even here we are not on safe ground, for, in the interval between x-rays, transitory cavitation may have occurred. The pathogenesis is certain when a tuberculoma is seen to replace a cavity on serial radiographs.

However, when an individual presents with a tuberculoma, there is no such help and no means of knowing. Interpretation of the morbid anatomy from the radiograph becomes pure guesswork, a common mental exercise in the earlier literature (vide Pierson, 1942). The presence of other disease may be in favour of an inspissated cavity but its absence does not militate against, and the same may be said for a pre-cavitary lesion. A similar dictum can be made with regard to the other clinical and radiological characteristics of these cases. The character of healing and activity may be the same in both.

The pathologist has only slightly less difficulty when faced with the resection or necropsy specimen, and especially when liquefaction of a pneumonic focus has



occurred, differentiation may be impossible. The only points on which reliance can be placed are :- (1) a caseous focus, before liquefaction, has a homogeneous centre firmly attached to its wall, and unlike the inspissated cavity, this cannot be washed off by water; (2) microscopic examination of the caseous pneumonic focus, stained for elastic fibres by the Van Gieson method, may show large portions of intact elastic structure outlining the former lung parenchyma, while in the inspissated cavity, only disorganised elastic elements may be seen on occasion; and (3) cartilaginous remnants may be seen running through a pre-cavitary focus.

Fortunately, differentiation between these two main histo-pathological varieties is of little more than academic interest. As Shamaskin, (1941), indicated in a study of inspissated cavities, from the clinical and therapeutic standpoint, there is little difference between them and caseous pneumonic foci. He found that the clinical prognosis of inspissated cavities was good, and this opinion was confirmed by Study and Morgenstern, (1949), in a clinical study of 24 cases. We have seen that this applies to tuberculomata as a whole, although in this series breakdown was more frequent than in the experience of these authors.

A further possibility which, so far, has not been discussed in detail is that a primary tuberculous lung focus may occur in rounded form and come within the radiological definition. Particularly in adults, it is

known that a primary lesion is frequently unassociated with radiographic evidence of hilar adenopathy and in such event, and in the absence of known Mantoux conversion, its differentiation from a post-primary lesion would be impossible. Happily, it can be excluded in most instances by the presence of a calcified complex, and this was the main reason why the early German workers, and almost all since, have disregarded the possibility. Kissin and Cohen, (1941), however, reporting 4 cases of tuberculomata, suggested that they may well represent healed primary lesions.

2 cases in this series were primary lesions and in 1 other, Case 35, who later died of pulmonary tuberculosis, it could not be excluded on examination of the resection specimen. In Case 15, a woman of 34, suggestive evidence of hilar adenopathy was later confirmed by calcification as the rather irregular parenchymal focus hardened, partially resolved, and calcified. The other was a resection case, (Case 39), a boy of 18, in whom tomography had failed to reveal any abnormality apart from a round lesion, and yet satellite foci and caseating lymph nodes in the lung root were found in the resected lobe. The main lesion was of unusual histology but the pathologist was definite in the opinion that the picture was that of a primary complex. New infiltration appeared shortly after operation. Recently yet another example of resection of a primary complex for the same reason has been seen, in which a post-operative tuberculous



12.7.40.



4.2.49.

Fig. 13. ? Primary Tuberculous Focus: Case 15.

Female. Aged 34 years. The rounded opacity, seen at the right hilum on the first x-ray, resolved and calcified at the same rate as the rather irregular parenchymal focus.



A.P. Tomograph (4 cm).

Fig. 14. Primary Focus: Case 39.

Male. Aged 18 years. Lesion found by Mass Radiography. Patient symptom free. All investigations negative, but culture of gastric washings was returned as positive for tubercle bacilli, after resection had been performed. Left lower Lobectomy : 29.11.49, (as slight enlargement on serial radiographs was suspected). The pre-operative diagnosis rested between malignant tumour and a tuberculoma. Pathological examination of the resected lobe revealed a primary tuberculous focus, surrounded by satellite tubercles, and associated with actively caseating tuberculous hilar glands. Note that, even with tomography this co-existent disease was radiographically invisible. Post-operatively, a small patch of infiltration has developed in the left upper lobe.



empyema necessitated later thoracoplasty.

Obviously, from the therapeutic viewpoint, it is of the utmost importance to endeavour to separate cases of primary tubercle from the others. Close regard must be given to the differential points already mentioned, and it is suggested that, in all doubtful cases, tomography already advocated as a routine measure, should become obligatory and search the hilar regions for occult adenopathy. Where the possibility exists, operative procedures are better avoided.

The proportion of cases which fall into each of these main pathological patterns is unknown, and only when the morbid anatomy of a large number of resection cases is available will this be clarified. The majority fall within the first two categories, and probably only a few are primary lesions. In this series, the resection cases have been divided as follows :-

Table 3. Histo-pathology of resection cases.

Histo-pathology	Case Numbers	Total
Post-primary caseous pneumonia	38, 40, 41.	3
Inspissated cavity	36, 37.	2
Primary focus	39.	1
Indefinite (possibly primary)	35.	1

## THE PROBLEM OF THERAPY.

Every tuberculosis physician is familiar with the difficulties of treatment of tuberculomata, and in dealing with the individual, he has little to guide him, apart from intuition, experience and certain general principles. In the literature, there is no study in the English language in which this problem, in all its aspects, has been discussed. In the past, close observation, bed rest, and artificial pneumothorax have been advised, but, in recent years, resection has been much vaunted as a panacea, and by some accepted as such, without due regard to scientific argument. There is, however, no general agreement that it deserves such a place of honour, although most would welcome its entry to the therapeutic field.

The foundations of any therapy lie in the observation that the agent used either assists Nature to effect improvement or cure, or supersedes Nature in efficacy. By medical treatment of tuberculomata, we are endeavouring to comply with the former precept; with resection, the latter. It is necessary to study these lines of treatment in relation to the natural history of the disease.

## GENERAL MEASURES.

The value of rest as fundamental in the treatment of phthisis has been undisputed through years of change, and all modes of placing the local disease in a favourable

position for healing are only supplementary to the broader principle of general rest. Toxaemia of any form or degree makes rest obligatory until it disappears, but, in general, it is indicated where any active focus exists. Tuberculoma is no exception and in the presence of symptoms or signs of activity, the patient should be rested until favourable progress, clinically and radiographically, seems assured.

Admission of all cases to a hospital or sanatorium bed for observation is, at the present time, quite impracticable, but would be the ideal initial step. Fortunately, it is often possible to recognise with reasonable accuracy a small proportion of cases in whom such a measure is unnecessary. These are the asymptomatic patients with hard lesions, perhaps containing calcium, in whom close out-patient surveillance with serial x-rays will suffice.

On 9 occasions, this latter course was adopted but, in 2, subsequent breakdown occurred. The other 7 remained in good health but, in one, a further round focus appeared silently and then resolved.

The duration of bed rest in the others will depend on several factors - not the least being the confidence of the attendant in his judgement and therapy. After the preliminary period of investigation, the patient with the apparently stable lesion may be allowed to resume his normal activities, attending the out-patient clinic periodically; the patient in whom activity is suspected

or evident, will be a candidate for the therapeutic arsenal - continued bed rest, collapse therapy, antibiotics, or resection.

Of the 16 cases treated by rest alone, half never demonstrated radiological activity and gradual return to normal life was allowed. In 7 of the other 8 cases, evidence of activity quickly disappeared without other treatment. In 2 of these, however, after apparent cure, further disease developed many years later. Only 1 case of those treated in this fashion failed to respond. Tension cavitation developed, the patient refused all further therapy, and returned home to poor domestic circumstances.

#### COLLAPSE THERAPY.

##### (1) Artificial Pneumothorax.

Assmann and his contemporary German workers advised therapeutic pneumothorax if "climatic-dietary" treatment failed - that is, if the lesion failed to regress or if retrogression occurred. (Here again must be added the rider that this advice was given for all sub-clavicular infiltrates, and no particular regard was given to the larger, circumscribed lesions). Straub, (1932), considered that no treatment had much effect. Coryllos, (1933, 1936), Eloesser, (1937), Shamaskin (1941), and others, were of the opinion that inspissated cavities were refractory to collapse therapy, and displacement of the lesion was all that was achieved.



However, in the presence of a tendency for the cavity to open and close or remain open, collapse therapy was indicated, with a possibility of effecting permanent closure.

In tuberculosis practice, many physicians still rely on this therapy for the active case, often on the pretext that, if it may do little good, it rarely causes harm. They hold the view that it may act as an insurance against breakdown, or if this has already occurred, spread disease many benefit and by alteration of the bronchial mechanics, healing of the active lesion may result. Others do not subscribe to this view, as the only result they have observed is displacement of the lesion, without alteration in its size or density, and without influence on its natural history.

Case Analysis: There were 8 pneumothoraces on 7 patients in this series. A good collapse was obtained in all but 1 (Case 32), where restraining adhesions were not divided.

In 1 patient (Case 21), it was instituted because of pregnancy, as a prophylactic measure, but in others, evidence of enlargement, breakdown, or spread was the reason for its use. In 1 (Case 18), however, close inspection of the x-rays fails to confirm such evidence although enlargement was stated to be the reason for collapse. No serious complications of pneumothorax therapy were observed. A small amount of pleural fluid developed in 3 cases and was followed by loss of the

pneumothorax in 2. A curious ribbon-like atelectasis of the segment in which the tuberculoma was situated appeared in 1 case, and 2 years later when it slowly resolved, the tuberculoma had gone with it. A collapsed lower lobe associated with pleural fluid was observed for a short time in 1 case before the pneumothorax was abandoned.

The therapeutic effect is difficult to assess. No harm came of it in any one case, apart from that ascribed to thickened pleura (2 cases). In all, radiological signs of activity disappeared, never to recur. Symptoms and sputum positivity where present, behaved similarly. Lest it be thought that this is the invariable course, mention must be made of 2 cases, from other sources, seen recently, and in whom the effect was less salutary. In 1 a "tension-type" cavity blew up soon after induction, with massive spread to the other side; in the other the lesion slowly enlarged and cavitated in typical tuberculoma-like fashion, under the pneumothorax, and proceeded to heal when the collapse was abandoned.

Pneumothorax appears to exert its effect, in these cases, mainly by virtue of alteration of the relative patency of the draining bronchus. Where it is closed, collapse therapy has no value and displacement of the lesion is all that can be anticipated. If there is a communication between the lesion and its bronchus, then it is a matter of chance whether isolation of the lesion,



6.12.46.



10.4.47.

Fig. 15. Bilateral Pneumothoraces for Tuberculomata: Case 31.

Female. Aged 23 years. Examined as a contact, and found to have a tuberculoma in the right upper zone and a small discrete focus in the left middle zone. As the sputum was positive on one occasion a R.A.P. was induced, (5.4.46). On year later, a L.A.P. was induced because of increase in size of the left-sided lesion. Both pneumothoraces are still maintained. On the right, all that remains is a fibrous streak; on the left, the lesion is more dense and slightly smaller. The patient is well.



21.9.42.



11.1.44.



15.10.49.

Fig. 16. An active lesion treated by Pneumothorax: Case 19.

Female. Aged 17 years. Progressive enlargement for 2 years with intermittent cavitation and local spread. R.A.P. induced (11.6.44), and maintained for 2 years. Patient has been symptom free throughout. Steady radiological improvement since induction of pneumothorax.



or full-blown cavitation results. Fortunately, from the present series, it would appear that the former is the more likely.

As it is impossible to compare these results with those expected by bed rest alone, the attempt will not be made. There is no evidence, however, that in a closed lesion artificial pneumothorax has any effect, nor is there anything to suggest that the rate of healing is accelerated, once an active focus is isolated by collapse. As, where no treatment is given, increase in density and later resolution and calcification occur slowly over many years.

The place of pneumothorax in therapy can only be in the treatment of the active lesion where its purpose is to convert activity to quiescence.

## (2) Other Collapse Measures.

Pneumothorax is the only form of collapse therapy advocated in the available literature. Obviously there is no place for thoracoplasty or extrapleural pneumothorax for the possible benefits are no more than can be expected from minor collapse methods, and the means does not justify this end.

Phrenic nerve interruption may have a limited place, either alone or supplemented by a pneumoperitoneum. It was performed as the sole collapse measure in 3 cases in this series - in 1 (Case 23), as a safeguard against breakdown in a patient who, on one occasion, had a positive

sputum; and in the other 2, for radiologically active lesions. Pneumothorax was not possible in one of the latter because of the presence of a pleural effusion (Case 22), and in the other phrenic crush, followed by avulsion, was preferred as the lesion, in the apex of the right lower lobe, developed during observation into a large tension cavity. Within 2 months of phrenic nerve crush, cavitation had disappeared and further progress was uneventful. All 3 did well.

As an alternative to pneumothorax, where collapse therapy is indicated, and where the former is unobtainable or contra-indicated, it is worthy of consideration.

#### ANTIBIOTICS.

Streptomycin was exhibited in 1 case where tension cavitation and spread occurred. The effect was most satisfactory, with reduction in size and inspissation of the cavity, and clearing of the spread disease. Follow-up is short but apparent stability has been obtained.

The value of this drug, where tension cavitation occurs, is accepted. Its effect on the more typical cavitation of tuberculomata is unknown. Theoretically, it is potentially dangerous. Increased patency of the draining bronchus, a common healing phenomenon with streptomycin, might result in open cavitation. It is unlikely to influence a closed lesion, as this is, in effect, a cold abscess of the lung.

## RESECTION.

### Historical Review:

In 1921, Jacobaeus removed a tuberculoma from the lung at operation, in the belief that it was a tumour. The patient died of tuberculous empyema. This is the first record of resection of such a lesion. As thoracic surgery advanced, reports of the successful removal of pseudo-tumoral tuberculous foci were published (Graham and Singer; 1936, Haight and Farris, 1939; etc.) and about the same time, the possibilities of planned resection were recognised.

In 1942, Thornton and Adams analysed all reported cases in which tuberculous tissue has been removed by operation, and in one third of the total, operation was performed without the knowledge that the lesion was tuberculous. Of a total of 80 resections, there were 16 instances of tuberculomata, in all of which tumour was the pre-operative diagnosis. There was one immediate death and 3 of the remaining 15 had developed further pulmonary phthisis.

Since then, with improvement of surgical technique and after care, and with the advent of antibiotics, resection has become a recognised procedure in certain forms of pulmonary tuberculosis, and many large series have been recorded (Overholt, et al. 1946, 1947, Bailey et al. 1949 etc.). In all these series, tuberculoma features in small percentage.



The present surgical outlook is reflected by Mc Mahon and Forsee, (1949) and Holmes Sellors and Hickey, (1949). The former, in a series of 35 resections for tuberculomata, stressed the hazards of diagnosis and of considering these lesions as benign or arrested, and advised exploratory thoracotomy or planned resection. The latter authors reporting 15 cases, in whom recovery after operation was "rapid and complete", assess the therapeutic problem as follows:- "The bias towards intervention is given by an element of doubt as to the presence of growth in some instances, and the knowledge that there is an abnormal and possibly unstable condition in the lung causes many patients to press for operation".

#### Discussion:

Few would gainsay the use of resection where bronchogenic carcinoma cannot be reasonably excluded after full investigation, but even here, indirect if flimsy criticism can be levelled against it. Carcinoma of the peripheral bronchi is more rapidly fatal than the central type of growth, and blood-borne metastases are early, (Tuttle and Womack, 1934). Five-year follow-up studies of post resection cases are as yet few, but make dismal reading. Whilst it is realised that every survival is salvage, in view of the uniformly fatal outlook if untreated, the question might be raised whether the poor prognosis of resected carcinoma justifies the danger of operation and the sacrifice of much valuable lung, when reasonable doubt exists as to the presence of such a



relatively benign lesion as a tuberculoma.

The place of resection in the treatment of tuberculoma per se is more assailable. In its favour, its protagonists claim many virtues. A potentially unstable lesion is extirpated with slight risk, thereby avoiding the dangers of breakdown and spread, and allowing the patient to return to normal life with the minimum of delay. In the face of such an idyllic state of affairs, attractive both to the patient and to the physician who is perhaps unhappy in mind and can offer no alternative, it may seem difficult, at first, to offer any destructive criticism.

Activity in some form has been seen in this series in half the patients and thus, their potential instability is amply proven. Half the patients, on the other hand, with simpler therapy or none at all, proceeded to heal without event. Some of these latter cases might not have attracted the surgeon's interest because of apparent radiographic innocence etc., but others were indistinguishable from lesions which subsequently broke down. It is safe to say that these cases did as well without resection as they would have done with it, and if it is to be considered, at least the asymptomatic patient, with the unchanging solid focus, should be excused resection.

When considering the remainder, the significant factor is their good prognosis when treated on more conservative lines. With a minimum follow-up of 3 years, 91% had healed or were progressing towards that end.

Only 2 cases still demonstrated activity in the tuberculoma and another had developed further disease after healing of the original focus. Only 1 of these can be assessed as being without the bounds of permanent cure.

There was, in the resection cases, 1 death due to broncho-pleural fistula, a direct result of operation, and 1 case showed new infiltration shortly after operation. The post-operative surveillance is of too short duration in all but 2 to allow the designation of apparent cure.

Accepting resection as comparable to other therapy in long-term results, can it be considered the treatment of choice by virtue of more rapid recovery and return to normal life? Following resection for pulmonary tuberculosis, most surgeons feel that a longer convalescence than is usual in non-tuberculous chest surgery is beneficial and necessary as an insurance against both immediate and distant complications. However, the time is short when considered in relation to the average invalidism of tuberculosis. Where no evidence of disease remains, the time from operation to full return to normal life can be reckoned in terms of months. In tuberculoma, where complete eradication of radiological disease is generally the rule, this period is usually in the region of 6 months, and it is rarely necessary to exceed this time as post-operative complications are uncommon. To this, however, may have to be added a considerable time for pre-operative investigation and observation, unless

routine operation is proposed. The average duration of invalidism in the uncomplicated case, treated conservatively, was, in this series, 5 months, and so here again, in the average case, resection has little to offer.

In those in whom activity occurred, however, the average period of economic loss is longer and, here, was in the region of 14 months. There was a considerable range between normal life throughout and total invalidism for  $3\frac{1}{2}$  years. As a generalisation, had successful resection been performed, from this viewpoint, this group would have benefited.

From the above arguments based on the clinical behaviour of tuberculomata, the procedure would appear to have little definitely in its favour when compared with other therapeutic methods, with the exception of giving a fair chance of shortening the duration of ill-health in a proportion of cases. It is not possible to justify the claim that it betters the results of more conservative therapy in the average case, or that potential instability vindicates its use. On the other hand, the results, both immediate and remote, are as good as might be expected from modern technique in expert hands on a limited, often closed and healing lesion. It offers an alternative form of therapy.

From the pathological viewpoint, there are further cautions to the use of resection. Tuberculosis is a systemic disease, frequently involving many organs.

Removal of one affected part does not necessarily mean cure. As practical politics this may carry little weight, but it is a fundamental point. Furthermore, it is becoming increasingly recognised that the actual involvement of the lungs with disease is frequently much more considerable than is expected from the radiograph, which, after all, can only demonstrate foci sufficiently large or dense to cast a shadow. An excellent example of this is Case 39, where, even tomography failed to reveal satellite foci and caseating glands, macroscopically evident in the removed lobe, and the fresh disease in the remaining lobe soon after operation may have developed from extension of such invisible foci.

Admittedly this bogey of radiologically invisible disease can be raised against any therapeutic measure, and generally counts for little. It is suggested, however, that a careful search of both lung fields by tomography should be made before the decision to operate is taken, and, if found outside the part to be resected, further consideration should be given to the advisability of the procedure. The post-operative physiological stresses on the remaining lung tissue may well be sufficient to stir these foci into activity. It must be remembered that tuberculoma as an indication for resection is in a different category from other forms of phthisis where greater risks are usually justified by the otherwise poor outlook.

In the discussion on pathology, it was seen



that a tuberculoma may fall into one of three patterns - post-primary caseous pneumonia, inspissated cavity, and primary focus. It is relevant to apply this pathological knowledge to therapeutic considerations.

Removal by operation of a primary complex is theoretically unsound, but, apart from this, the operative and post-operative hazards may be considerable. Interruption of caseating hilar glands and lymphatics is a potent source of complications.

Likewise, resection of an inspissated cavity is generally contra-indicated in the light of present knowledge. Pathological evidence has been summoned to support the concept that such a lesion constitutes a common method of cavity healing and clinical material presented by Shamaskin, (1941), and by Study and Morgenstern, (1949), of radiologically proven cases confirms their benignity. The latter authors, whose cases were peculiarly lacking in complications, state that the use of a major surgical procedure is illogical, but the former, recognising that there is no constant course, is less biased, merely affirming that when no evidence of activity exists they should be regarded as closed cavities and treated accordingly.

On the theoretical argument that a tuberculoma of the lung was a conglomerate tubercle, identical with such lesions in the brain or elsewhere, Dahl-Iversen, (1946), proposed resection in all cases - "as it is known that" in these other sites "they continue to grow and must be

removed operatively". At least 1 of his 3 cases, if not all, was an inspissated cavity. This argument for resection is mentioned only to be rejected.

To summarise, the place of resection is difficult to define. The relative benignity of these lesions is the main objection to its frequent use. Both clinically and pathologically there are other arguments against it. In those cases in whom evidence of activity is absent, it is better avoided. Where activity is present, either at the outset or during observation, it forms an alternative therapy capable of rapid and lasting cure. Each case must be judged on its merits after the most careful assessment.

#### Case Analysis:

In this series, the reason for operation was diagnostic error in 3, diagnostic doubt in 2, and only in the remaining 2 was the operation a definitive treatment directed against tuberculoma. There was evidence of radiological enlargement in 2 of the first 5 cases. Both the diagnosed tuberculomas showed clinical and radiological activity.

To attempt comparison between the results obtained and those expected by other means in the individual patient is a somewhat sterile task. With one exception (Case 35) where operation precipitated a train of events which led to the grave, all are alive and well at the time of report, but one of these has developed further disease. The duration of follow-up in all but 2 is extremely brief.

The 3 cases in whom no evidence of actual or anticipated breakdown was present (Cases 36, 37 and 38) might have done as well without resection, had a watchful policy been permissible. The same may be said of Cases 40 and 41, but here it is possible that cure may have been achieved with greater rapidity than by other means.

Table 4. Analysis of 41 cases in relation to therapeutic results.

No. of Cases	Type of Therapy	Activity		Results			
		Absent	Present	Cure	Apparent Cure	Active P.T.	Death
7	Observation only	6	1	5 1	1 -	- -	- -
16	Bed rest only	8	8	4 -	4 5	- 3*	-
7	Pneumothorax	2	5	2 3	- 2	- -	- -
3	Phrenic Paralysis	1	2	1 1	- 1	- -	- -
1	Streptomycin	0	1	-	1	-	-
1	Resection: (a) Pneumonectomy	0	1	-	-	-	1
6	(b) Lobectomy	3	3	- -	3* 2*	- 1+	- -
41		20	21	17	19	4	1

Note: Cure: a healing process observed for 5 years or more.  
Apparent cure: healing process observed for less than 5 years.

\* : In one of these cases, the tuberculoma healed; in another late cavitation occurred after 10 years.

+ Follow-up under 1 year in all but 2 of the lobectomy cases.

CONCLUSIONS AND SUMMARY.

1. This study is based on a series of 41 consecutive cases of tuberculoma of the lung, seen at the Brompton Hospital for Diseases of the Chest, in whom, with the exception of 7 cases subjected to pulmonary resection, a follow-up, varying between 3 and 15 years, has been obtained.

This series, by virtue of inadequacy in numbers, short duration of follow-up, and other deficiencies, does not constitute a scientific basis for any final conclusions on the subject, but it serves to throw some light on the various problems associated with these lesions.

2. Tuberculoma of the lung is defined. The term should be used only to denote a radiological entity - the rounded, homogeneous, pulmonary opacities of tuberculosis. When employed in this fashion, it provides the most acceptable descriptive term for these lesions.

3. The diagnostic problem in all its aspects is discussed, with particular reference to the difficulties of differential diagnosis. Confusion with primary bronchogenic carcinoma is the greatest hazard, and clinical differentiation is often difficult. The history of illness, age of the patient, sputum findings, and the radiographic characteristics of tuberculomata are the salient diagnostic accessories.

The importance of tomography is stressed, and its use advocated as a routine measure. Not only does



it help to elucidate the true radiographic nature of the lesion, but it may determine the presence of other tuberculous disease in the lungs or hilar adenopathy - findings of much importance in relation to both diagnosis and treatment.

Exploratory thoracotomy as a diagnostic measure is deplored, as is routine resection in every doubtful case. Operation, however, is undoubtedly justified, when, after most careful assessment, the scales weigh in favour of primary neoplasm.

4. The natural history of these foci has received but cursory attention in the past, and yet the predominant opinion of present-day observers accords to them a poor prognosis unless radically treated.

In this series, 31, (91%), of the 34 cases treated conservatively, were alive and well at the end of surveillance. There were no deaths, but the remaining 3 patients have active pulmonary tuberculosis. Despite this good prognosis, 50% demonstrated instability of the lesion at some time, in the form of enlargement, cavitation, or the development of fresh disease; the remainder healed without event.

These results are similar to those obtained by Eriksen, in Norway, in the only other study of this kind.

5. Their pathology is varied and three distinct patterns are observed:- (a) post-primary caseous pneumonia, (b) inspissated cavity, and (c) primary focus.

Differentiation of cases into these histo-pathological

groups by clinical and radiological means is normally impossible; and even microscopy can fail.

6. The therapeutic problems presented by tuberculomata are such that it is often a matter of considerable difficulty to envisage the best line of treatment for the individual patient.

In recent years, a certain bias towards resection has developed, encouraged by reports of good surgical results. In the literature, little if any criticism has been levelled against its use. That it has a part to play in therapy is admitted, but evidence has been produced in favour of restriction of its sphere. It has no place in the symptomless patient with the unchanging lesion, but, in selected cases, where activity is manifest, it may allow a more rapid return to normal life.

Finally, a plea is made for a more optimistic outlook as regards the natural history of tuberculomata and in favour of a more conservative therapeutic policy. Bed rest, possibly assisted by minor collapse, will turn the average active case towards cure. With the healing case, no interference is necessary.

REFERENCES.

- Amberson, J.B. (1936). Amer. Rev. Tuberc., 33, 269.
- Assmann, H. (1925). Beitr. klin. Tuberk., 60, 527.
- Assmann, H. (1921). Roentgendiagnostik innerer Krankheiten, Liepsig.
- Assmann, H. (1930). Radiology, 14, 93.
- Auerbach, O., and Green, H. (1940). Amer. Rev. Tuberc., 42, 707.
- Bailey, C.P., et al. (1949). J. thorac. Surg., 18, 36.
- Beitzke, L. (1931). Ergebn. ges. TuberkForsch., 3, 1.
- Bruck, S. (1934). Amer. J. Roentgenol., 31, 319.
- Coryllos, P.N. (1933). J. Amer. med. Ass., 100, 480.
- Coryllos, P.N. (1936). Amer. Rev. Tuberc., 33, 639.
- Dahl-Iversen, E., and Fleming Møller, P. (1946). Acta chir. Scand. 94, 243.
- Derscheid, G., and Toussaint, P. (1938). Arch. med.-chir. Appar. resp., 13, 115.
- Dillwyn Thomas. (1948). Tubercle, Lond., 29, 216.
- Eloesser, L. (1937). J. thorac. Surg., 7, 1.
- Eriksen, J. (1949). Nord. Med., 42, 1530.
- Fruchter, J.M. (1935). Radiology, 25, 609.
- Graef, S. (1935). Ergebn. ges. TuberkForsch., 7, 312.
- Graham, E.A., and Singer, J.J. (1936). J. thorac. Surg., 6, 173.
- Haight, C., and Farris, J.M. (1939). J. thorac. Surg., 9, 108.
- Holmes Sellors, T., and Hickey, M.D. (1949). Thorax, 4, 82.
- Houghton, L.E. (1950). Tubercle, Lond., 31, 50.
- Jacobaeus, H.C., and Key, E. (1921). Acta chir. Scand., 53, 573.

- Kayne, G.G., Pagel, W., and O'Shaughnessy, L.O. (1948).  
Pulmonary Tuberculosis, London.
- Kissin, M., and Cohen, A.G. (1941). Ann. intern. Med.,  
14, 1216.
- Mc Mahon, H.W., and Forsee, J.H. (1949). J. thorac. Surg.,  
18, 431.
- Overholt, R.H., et al., (1947). Amer. Rev. Tuberc., 55, 198.
- Overholt, R.H., et al., (1946). J. thorac. Surg., 15, 384.
- Pagel, W., and Simmonds, F.A.H. (1939). Amer. J. med. Sci.,  
197, 281.
- Pagel, W., and Simmonds, F.A.H. (1942). Amer. J. med. Sci.,  
203, 177.
- Pierson, P.H. (1942). Amer. Rev. Tuberc., 45, 75.
- Shamaskin, A. (1941). Amer. Rev. Tuberc., 44, 310.
- Stefko, K. (1928). Beitr. klin. Tuberk., 69, 247.
- Straub, H. (1932). Ztschr. klin. Med., 121, 515.
- Study, R.S., and Morgenstern, P. (1949). Amer. Rev. Tuberc.,  
59, 53.
- Thornton, T.F., and Adams, W.E. (1942). Surg. Gynec. Obstet.,  
75, 312.
- Tuttle, N. M<sup>C</sup>C., and Womack, N.A. (1934). J. thorac. Surg.,  
4, 125.



## APPENDICES.

Brief case summaries of 41 patients, suffering from tuberculoma  
of the lung, tabulated according to original grouping (Page 5)  
and method of treatment.

SURVEILLANCE ONLY.

Progress notes	Radiographic appearance at completion of observation	Invalidism (months)	Follow-up (years)
-	Resolution and calcification.	0	12
-	Unchanged.	0	$3\frac{1}{4}$
-	Calcification, but size unchanged. Also calcification of adjacent infiltration previously unseen.	0	6
-	Resolution and calcification.	0	$10\frac{3}{4}$
-	Resolution and calcification.	0	$11\frac{1}{2}$
Developed similar rounded lesion which partially resolved, leaving calcium deposit.	Smaller and more dense, with early calcification.	0	7

# BED REST AND SUBSEQUENT SURVEILLANCE.

Progress notes	Radiographic appearance at completion of observation	Invalidism (months)	Follow-up (years)
months later, following an H'ptysis, developed eccentric comma-shaped cavitation. Cyst diagnosed, but sputum later +ve.	Smaller and more dense.	5	5
months later, lesion cavitated, and patient developed T.B. broncho-pneumonia (Z.) with mixed empyema. Sputum +ve. Resection drainage and bed rest resulted in good recovery.	Resolution and calcification. Pleural scars and rib-resection deformity at R. base.	11	3½
enlarged, with 3 small eccentric cavities. In 4 months of discovery, cavitation appeared. Sputum -ve.	Size unchanged. More dense with early calcification. Also calcium deposits at both hila.	8	3½
Tomography showed adjacent infiltration, probably present ab initio.	Size unchanged, but slightly more dense.	7	3
-	Resolution and early calcification.	6	7
al effusion - lymphocytic and sterile culture - cleared within 5 months.	Smaller, more dense, and better definition.	6	3
-	Resolution and calcification.	3	4½
-	Smaller, increased density, and ? early calcification.	9	14
-	Resolution to an irregular fibrous streak, and calcification. Also calcium deposits at R. hilum in position of previous rounded opacity.	9	9
-	Size unchanged, early calcification.	2	4
months later, developed small ipsilateral lesion which resolved uneventfully. Years later, tuberculoma had resolved to a fibrous streak. After 2 further years, active pulmonary T.B. developed in contralateral lung.	Tuberculoma remains healed. Active cavitary tuberculosis present in the L. lung.	4 (+ past 4 years)	8

Case No.	At first attendance				Reason for collapse therapy
	Sex & Age	Site (zone) & Size (cms) of lesion	Radiographic appearance of lesion	Clinical notes	
18	F 24	R.U.Z. $1\frac{1}{4} \times 1\frac{1}{4}$	Soft, good definition, obscured by ribs and clavicle. Well seen on tomography.	No symptoms, E.S.R. 15	Possible enlargement after 1 year's observation - not confirmed on reassessment of films.
19	F 17	R.U.Z. $3 \times 2\frac{1}{2}$	Soft, good definition, with 2 eccentric kidney-shaped translucencies.	No symptoms.	Progressive enlargement over 2 years until size $5 \times 4$ cms. By then, cavitation had disappeared. Also developed rounded peripheral infiltrates.
20	F 21	R.M.Z. $2\frac{1}{2} \times 2\frac{1}{2}$	Medium density, hazy definition peripherally, with 2 small translucencies.	No symptoms.	Progressive enlargement to $3\frac{1}{2} \times 3\frac{1}{2}$ cms and appearance of adjacent soft infiltration after 1 year's observation. Sputum culture +ve.
21	F 21	R.U.Z. $2\frac{1}{4} \times 2$	Soft, good definition.	No symptoms.	Pregnancy. Induced after 7 months observation in which there had been no change.
22	M 25	L.L.Z. $3 \times 3$	Partially obscured by vascular shadows in routine films. Homogeneous and clearly defined on tomography.	Pleural pain, H'ptysis.	After 18 months, sputum culture +ve and developed small round lesion and infiltration at L. apex. 6 months later, L. pleural effusion (T.B. +ve). L. phrenic nerve then crushed.
23	F 30	L.U.Z. $2\frac{3}{4} \times 2\frac{3}{4}$	Soft, good definition.	No definite symptoms, Sputum +ve.	As a possible safeguard 9 months later.



- COLLAPSE THERAPY.

Type of collapse	Duration (years) of collapse	Progress notes	Radiographic appearance at completion of observation	Invalidism (months)	Follow-up (years)
R.A.P.	$3\frac{1}{2}$	Remained stationary 1 year, then segmental collapse developed in relation to lesion. This resolved after 2 years and lesion no longer seen. A.P. abandoned by election.	Complete resolution.	10	5
R.A.P.	$2\frac{1}{3}$	Developed trace of fluid. A.P. abandoned because of rapid obliteration. Patient remains well.	Smaller ( $2\frac{1}{2} \times 2$ cms) and more dense. Small, hard opacities, peripheral to lesion.	10	7
R.A.P.	$2\frac{1}{2}$	Satisfactory R.A.P. still maintained. Pleural fibrin balls present. Patient remains well.	Smaller ( $3 \times 3$ cms) and more dense with clear cut margins.	12	$3\frac{1}{2}$
R.A.P.	$1\frac{1}{4}$	Developed fluid after 6 months, followed by collapse of R.L.L. A.P. maintained further 9 months, then abandoned. Patient remains well.	Resolution. Small speck of calcium present. Wide pleural shadow.	6	5
L. phrenic crush	-	Pleural effusion cleared in 3 months. Patient well since.	Smaller ( $2\frac{1}{2} \times 2\frac{1}{2}$ cms) and early calcification. Resolution and hardening of L. apical infiltration.	18	$4\frac{1}{2}$
L. phrenic crush	-	Remains well. No x-rays available until $8\frac{1}{2}$ years later.	Resolution and calcification.	15	9

Case No.	At first attendance			Clinical notes
	Sex & Age	Site (zone) & Size (cms) of lesion	Radiographic appearance of lesion and other disease	
24	F 36	L.M.Z. 2 x 2	TBoma: Dense, good definition, slightly irregular outline. O.D. : Several small hard spots, medial to lesion.	Vague symptoms.
25	F 32	L.U.Z. 2 $\frac{1}{2}$ x 2	TBoma: Medium density, good definition, irregular outline. O.D. : Soft mottling below and peripheral to lesion.	H'ptysis, General ill-health.
26	F 30	R.U.Z. 2 $\frac{1}{2}$ x 2 $\frac{3}{4}$	TBoma: Varying density, poor definition superiorly, irregular outline. O.D. : Soft infiltration peripherally in 1st - 3rd interspaces (R.)	H'ptysis, General ill-health.
27	F 20	L.U.Z. 3 $\frac{1}{4}$ x 3	TBoma: Soft, poor definition inferiorly, slightly irregular outline. O.D. : Infiltration in 1st and 2nd interspaces (L.), and at R. apex.	No symptoms.
28	F 27	R.M.Z. 2 $\frac{1}{2}$ x 2 $\frac{1}{2}$	TBoma: Medium density, poor definition peripherally. O.D. : Adjacent infiltration; also slight infiltration at R. apex. (Note: Normal x-ray, 2 years previously.)	H'ptysis, Sputum +ve, E.S.R. 20.
29	F 15	R.M.Z. 2 $\frac{1}{2}$ x 2	TBoma: Soft, good definition, except medially where it fuses with hilar shadows; small crescentic translucency. O.D. : Ill-defined infiltration in 3rd interspace (R).	Pleural pain, General ill-health, Sputum +ve, E.S.R. 18.
30	M 21	R.M.Z. 3 x 2 $\frac{3}{4}$	TBoma: Soft, hazy definition superiorly; eccentric translucency. O.D. : Further soft rounded lesion, lateral to hilum, and soft infiltration in L.L.Z.	Pleural pain, H'ptysis.

- SURVEILLANCE ONLY (CASE 24).
- BED REST AND SUBSEQUENT SURVEILLANCE (CASES 25 - 30 INCLUSIVE).

Progress notes	Radiographic appearance at completion of observation	Invalidism (months)	Follow-up (years)
Close surveillance for first 3 years only.	TBoma: No alteration either in size or density. O.D. : Calcification.	0	6
After 1 year, calcification commenced both in TBoma and O.D. TBoma maintained outline for further 1 year, when resolution commenced	TBoma: Resolution and calcification.	5	4½
In hospital for 3½ months. Clinical and radiological improvement during this time. Seen again 10 years later, complaining of frequent attacks of pleurisy. Sputum +ve.	TBoma: Cavity with fluid level in same site; adjacent fresh disease. O.D. : Calcification.	3½ + past 9 months	11
TBoma slowly grew smaller and more dense. After 3 years, calcium appeared. O.D. resolved within 1 year apart from small rounded focus at R. apex.	TBoma: Smaller and more dense with calcification. O.D. : Resolution, apart from calcifying focus R. apex.	12	7
2 months later, 2 small translucencies developed but disappeared rapidly. TBoma did not enlarge. 3 years later, translucencies reappeared for a short time. Then lesion became smaller, with gradual resolution.	TBoma: Resolution and early calcification. O.D. : Resolution on R. Hardening of infiltration at L. apex.	10	6
6 months later, the O.D. developed into a TBoma (2 x 2 cms), which showed a small eccentric translucency. This gradually resolved thereafter. The main lesion cavitated after 1 year and cavitation has persisted.	TBoma: Large cavity with fluid level. O.D. : Became a TBoma; resolution almost complete.	42	3½
In subsequent x-rays, varying cavitation with local spread - at times homogeneous, and at other times a large tension cavity. Diagnosed as infected cyst until sputum +ve, 1 year later. Received 35 gms Streptomycin. In the past year, the lesion has been homogeneous and is becoming smaller and more dense.	TBoma: Now 3½ x 2½ cms and dense; no cavitation present. O.D. : Gradual resolution.	3 + later 12	3½



Case No.	At first attendance				Reason for collapse therapy
	Sex & Age	Site (zone) & Size (cms) of lesion	Radiographic appearance of lesion and other disease	Clinical notes	
31	F 23	R.U.Z. $2\frac{1}{4} \times 1\frac{3}{4}$	TBoma: Soft, good definition. O.D. : Vague localised opacity in 3rd inter-space (L.)	Sputum +ve.	R.A.P. induced as a precautionary measure because sputum +ve. 6 months later, the lesion on the left became larger and the sputum again +ve. L.A.P. then induced.
32	F 34	R.U.Z. 4 x 4	TBoma: Medium density, hazy definition superiorly and medially. O.D. : Soft infiltration above and peripheral to lesion.	Cough, etc., Sputum +ve.	TBoma cavitated, and further infiltration appeared at R. apex and in L.M.Z. After observation for 1 year, R.A.P. induced.
33	F 34	L.U.Z. $2\frac{1}{2} \times 2\frac{1}{2}$	TBoma: Soft, hazy definition, with eccentric translucency. O.D. : 2 small homogeneous opacities inferior to lesion.	H'ptysis, Sputum +ve.	Refused treatment but eventually consented because of ill-health. Cavitation persisted. L.A.P. induced 1 year later.
34	F 27	R.M.Z. 4 x 4  L.M.Z. 2 x $1\frac{1}{2}$	TBomas: (1) The appearance is that of multiple cavitation in a large TBoma. (2) Soft good definition. O.D. : Soft infiltration adjacent to both lesions.	Sputum +ve, No symptoms.	R. phrenic crush 2 months later, followed by avulsion in a further 9 months, for activity in cavitory lesion in apex of R. lower lobe.



- COLLAPSE THERAPY.

Type of collapse	Duration (years) of collapse	Progress notes	Radiographic appearance at completion of observation	Invalidism (months)	Follow-up (years)
R.A.P. L.A.P.	4 3	Both pneumothoraces have been maintained since, without event.	TBoma: Resolution - only a small linear streak remains. O.D. : Became a TBoma (2 x 2 cms), now smaller and more dense.	9	4
R.A.P.	13	Adhesions were not divided. Contra-selective collapse resulted in cavity closure and A.P. has been maintained since. Re-expansion unlikely because of pleural thickening.	TBoma: Calcium deposits in position of former lesion. O.D. : Hard scarring.	24	14
L.A.P.	2	Cavity closure resulted from collapse. A.P. abandoned by patient's default. Developed Lupus 11 years later.	TBoma: Resolution and calcification. O.D. : Resolution and calcification. Also some calcium deposits at L. apex.	14	14½
R. phrenic paralysis.	permanent	All evidence of cavitation disappeared within 2 months of phrenic crush. Both lesions hardened; then, after 4 years, resolved completely, leaving only calcium deposits.	TBomas: (1) Resolution and calcification. (2) Resolution and calcification. O.D. : Resolution - only a few linear streaks remain.	10	14

Case No.	Sex and Age	Pre-operative diagnosis	Reason for diagnosis or operation	Investigations done	Type of resection	Date of operation	Clinical notes
35	F 29	Bronchogenic Carcinoma.	Enlarging lesion.	Sputum, E.S.R., Serial x-rays.	R. pneumonectomy.	7.5.41	Cough, H'ptysis.
36	F 35	Pulmonary tumour, ? Neuro-fibroma.	Malignancy suspected.	Diagnostic A.P., E.S.R., Sputum.	R. upper lobectomy.	26.1.43	Cough, Pleural pain.
37	M 51	Bronchogenic Carcinoma.	Carcinoma cells in sputum. Cancer age group.	Sputum, Bronchoscopy.	R. upper lobectomy.	27.5.47	No symptoms.
38	M 37	? Pulmonary TB ? Carcinoma.	No change on serial films.	Gastric lavage, Bronchoscopy, Tomography.	R. upper lobectomy.	18.10.49	No symptoms.
39	M 18	? Pulmonary tumour, ? Tuberculoma.	Enlarging lesion.	Gastric lavage, Tomography, Mantoux +ve.	L. lower lobectomy.	29.11.49	No symptoms.
40	M 28	Tuberculoma.	Enlarging lesion. Sputum culture +ve (scanty.) Operation as treatment of choice.	Gastric lavage, Bronchoscopy, Tomography, Serial x-rays.	Segmental resection of basal segments of R. lower lobe.	24.3.50.	No symptoms.
41	M 34	Tuberculoma in apical segment R.U.L. with adjacent infiltration.	Sputum culture +ve. Enlargement and ? cavitation of lesion. Operation as treatment of choice.	Sputum, Bronchoscopy, Tomography, Serial x-rays.	R. upper lobectomy.	25.3.49	Frequent small H'ptyses.

RESECTION.

Pathology	Result	Invalidism (months)	Post-operative follow-up (years)
A mass of fibrous tissue and caseation, surrounded by a cellular reaction with a few typical tubercles. Active tuberculous hilar gland.	Developed mixed empyema and broncho-pleural fistula. Died 18.4.43.	28	1 $\frac{7}{8}$
Tuberculous tissue, mainly fibro-caseous, with small areas of calcium. At periphery, there is a narrow layer of tuberculous granulation tissue.	Apparent cure.	6	4 $\frac{1}{2}$
Dense pleural adhesions overlying lesion. Oval cavity filled by caseous material, surrounded by a narrow zone of dense fibrous tissue. An inspissated cavity, resulting from occlusion of the bronchus by fibrous scar tissue.	Apparent cure.	5	2 $\frac{1}{2}$
Situated immediately below the pleura, there is a circumscribed focus of caseous tuberculous pneumonia. No enlarged glands present.	Apparent cure.	6	$\frac{1}{2}$
Scar on pleura overlying lesion. Oval mass of tuberculous caseous pneumonia, not yet liquefied. At the upper end of this mass, there are about 12 small foci measuring 2 - 3 cms in diameter. Regional lymph nodes show caseation. Around the lesion are small areas of tuberculous pneumonia. This is a primary lesion. (Note: A +ve sputum culture result was returned after operation.)	Fresh infiltration in L. upper zone appeared after operation.	Still in San.	$\frac{1}{3}$
Spherical tuberculoma 1 $\frac{1}{2}$ inches in diameter, with a central caseous area about $\frac{1}{2}$ inch in diameter. This represents a solid tuberculous focus which is undergoing central necrosis.	Apparent cure.	Still convalescent.	$\frac{1}{3}$
Rounded area of caseous tuberculous pneumonia lying in apical segment of R.U.L., which has destroyed the main apical bronchus, the course of which can be visualised by the presence of cartilaginous remnants. In addition other small scattered foci are present in apical segment.	Apparent cure.	8	$\frac{3}{4}$

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